

URBAN AND REGIONAL LAND USE ANALYSIS:
CARETS AND CENSUS CITIES EXPERIMENT PACKAGE

SKYLAB/EREP INVESTIGATION NO. 469
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a. Overall status, including problem areas and significant progress to date:

During the period of this report we received 9" x 9" enlargements of Skylab 2 S-190A photography which had already been received in contact print form. The enlargements, though containing no additional information content, are easier to use. For analytical work upon which quantitative results can be obtained, however, the land use data derived from the Skylab imagery must be mapped onto one of the reference scales used with the high-altitude aircraft or ERTS data. Our approach thus far to this problem has been to order 1:100,000 scale enlargements of the Skylab data, determine the degree of conformance with test site base maps in the UTM projection, and if satisfactory, proceed to map at that scale from the Skylab data. The results of this and other possible approaches to the problem of obtaining quantitative data sets from the Skylab imagery will be reported later.

Work has continued on the land use climatology portion of the investigation, in preparation of receipt of thermal data from the S-192 scanner. Discussion of this work is elaborated below.

b. Recommendations concerning decision and/or actions required to ensure the attainment of the experiment's scientific objectives:

Some comments relative to this are contained in section d. below.

c. Expected accomplishments during the next report periods.

- (1) continuing preparation of land use maps and change maps from the best available Skylab data for mandatory test sites

- (2) monitoring Houston telecorder for schedules of Skylab 4 passes over Baltimore test site for the land use climatology experiment
- (3) continuing work on the data processing techniques necessary to bring aircraft scanner data (and later Skylab S-192 data) into register with the map used for displaying the output from the "urban climate simulator"; this is a key portion of the land use climatology portion of this investigation.

d. Significant results and their relationship to practical applications or operational problems.

The arrival of the so-called "energy crisis" makes the portion of this experiment dealing with land use climatology of perhaps more immediate significance than before, since in addition to helping us understand the processes of climatic change associated with urbanization, the knowledge obtained may be useful in assigning an "energy balance impact" factor to proposed changes in land use in and around cities. Thermal maps derived from S-192 data are to be used as a measure of the energy being radiated into space from the mosaic of different surfaces in and around the city. With the exception of tiny quantities of energy from the interior of the earth and a yet undetermined amount of energy released by man's activities (as for example through the combustion of fossil fuels) the primary source of this energy which is sampled by the Skylab S-192 scanner is the incoming solar radiation received at the earth's surface at the time of the Skylab data take, with added increment of energy lagged by temporary storage from previous solar input into soil, water, concrete, etc. Relationships among the various factors that contribute to the surface temperature are well-known from energy-balance climatology. Spatial distribution of the various energy-balance parameters at scales appropriate to the study of metropolitan regions, however, are less well-known owing to the difficulty and expense that would be involved in extending ground

networks of instrumentation. It is to precisely this scale of investigation that the Skylab data are to be addressed.

But while presenting excellent spatial sampling potential for a metropolitan area test site, the Skylab data permit a very poor temporal sampling opportunity, owing to the large number of factors beyond the investigator's control that determine when data will be taken over a given test site. Distribution of surface temperature varies considerably over a given S-192 field of view during even a single diurnal cycle. Therefore our strategy is to augment the thermal maps derived from S-192 with a modeling technique developed by Dr. Samuel Outcalt, one of our Skylab co-investigators, which enables the simulation of a number of components of the surface energy balance, calculated at regular time intervals throughout the day or year. Empirical data from the precise time of the Skylab data take can then provide a check of the validity of the model's predictions, and a measure of its accuracy. Dr. Outcalt's surface climate simulator accepts as input the following types of data:

- | | |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| (1) Temporal data | solar elevation
radius vector of sun |
| (2) Meteorological data | sky radiant temperature
dust content
air temperature
wind velocity
air relative humidity
precipitable water
station pressure |
| (3) Geographical or land-use-related data | soil volumetric heat capacity
soil thermal diffusivity
surface roughness
albedo
wet fraction
shadow fraction |

Incidentally, techniques using remote sensing are possible for obtaining the last four types of data listed above, and are being explored or utilized in this investigation. Output from the model are time-dependent calculations at hourly solar time increments of the following parameters:

- | | |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (1) Solar radiation | extra-terrestrial radiation
beam radiation
diffuse hemispherical
radiation
backscattered reflected
hemispherical radiation
total incoming solar
radiation |
| (2) Surface energy transfer | net radiation
soil heat flux
sensible heat flux
latent heat flux
surface temperature |
| (3) Soil temperature matrix | soil temperature at 4
depths |

Preliminary tests on the performance of the model are still underway, using data from the airborne multispectral scanner flown as part of the NASA aircraft program over the Baltimore test site. Early results look extremely promising. The key component of the Skylab data set required for testing of the model and completing the land use climatology portion of the EREP Investigation No. 469 is the thermal map to be prepared from channel 13 output of the S-192 multispectral scanner. Ancillary data on land use and albedo from other channels and from the photography will be helpful in assessing the values of other parameters, but will be of no use in deriving a display of surface temperature. Therefore we wish to re-stress the importance of the S-192, channel 13 data for this investigation

If tapes from the S-192 are not available in machine-readable form so that energy values can be related to

map locations, we will have to go through a laborious and inherently less-accurate procedure involving optical integration of data displayed on the film transparencies, making an assumption about the relationship of film density to actual energy values. Prior work by Dr. Robert Pease, another project co-investigator, proves that this procedure is feasible. We have neither computer capability nor data processing funds in our contract to enable us to do initial noise-reduction and rectification processing of the raw S-192 tapes. As a back-up to cover the eventuality that NASA may be unable to provide us with clean derivative tapes from the S-192, Dr. Pease is improving and refining his method for optically integrating the display on the film read-out from S-192; the refined procedure enables combining the basic data compilation and processing with hand-operated digitizer and mini-computer linkage. Owing to the uncertainty about the quality of S-192 thermal data from either Skylab 2 or 3 missions over the Baltimore test site, we have discussed with project officials in Houston the possibility of substituting better data that may have been obtained from other test sites. Whether this can be done without impacting this investigation's funding and timing will require further discussion. A major factor here is the considerable amount of work on the Baltimore site already done by Dr. John Lewis, another project co-investigator. Dr. Lewis has been making the ground observations necessary for calibrating the thermal remote sensor data and has also been obtaining supporting data from that test site on surface roughness, wet fraction, and shadow fraction, necessary for calibrating the model for this specific application utilizing the Skylab data.

Because of the considerable amount of work that our team has already put into the land use climatology experiment, including work with data from the aircraft program prior to the initiation of Skylab, we are anxious to complete a satisfactory test of the concepts that have been developed under the auspices of this investigation as expeditiously as possible, as the implications are pregnant with possibilities of follow-on research and development. If successful, these techniques could lead to a methodology for simulating the thermal characteristics

of any proposed land use pattern for a developing metropolitan region. In considering alternative regional plans, for example, the magnitude of the urban heat island could be either increased or decreased depending on the planning goals and energy consumption problems of the area in question. Increasing the urban heat island would result in a saving in energy requirements for space heating at night and in the winter; in the summer, however, an increased urban heat island results in increased energy use for air conditioning, which has an unfortunate feedback resulting in further increase in air temperatures and further need for air-conditioning. Whether we are at the stage where we can talk about manipulating these basic energy-balance factors for our own advantage will depend on the degree to which we can increase our understanding of the basic environmental processes involved; through too-rapid changes in land use we have already succeeded in manipulating the environment unwittingly to our disadvantage in many cases.

e. Summary outlook for the remaining effort to be performed.

No change from last report.

f. Travel summary and plans.

None, except for travel to make ground truth observations as may be required for Skylab 4 data takes.

Approved:



Robert H. Alexander
Principal Investigator

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